Utility Energy Efficiency Programs and Experience 5

With ample untapped opportunities to save electricity, demand rising but long-term growth rates uncertain, and powerplant construction costs soaring, it is not surprising that energy efficiency has become the byword for cost-conscious consumers, regulators, and utilities seeking new ways to hedge future strategies. The potential of energy efficiency as a means to lessen the environmental impacts of energy use has also attracted the interest of conservationists. The prospective new business opportunities have garnered the attention of energy service companies and equipment manufacturers and vendors, as well as utilities.

This chapter looks at utility programs to influence customer energy use and how they are incorporated in utility resource options. State government efforts and regulatory treatment of utility-sponsored conservation and efficiency programs are discussed in chapter 6.

SCOPE OF UTILITY ENERGY EFFICIENCY PROGRAMS

U.S. utilities and State regulators have now had more than a decade's worth of experience with utility-sponsored energy efficiency programs. Broadly speaking, energy efficiency programs are aimed at reducing the energy used by specific end-use devices and systems without degrading the services provided. Such savings are generally achieved by substituting technically more advanced equipment to produce the same level of energy services (e.g., lighting or warmth) with less electricity.[1] Energy efficiency programs are sometimes referred to as energy conservation programs. However, because to some people the term

[1] *Eric* Hirst and Carol Sabo, *Electric Utility DSM Programs: Terminology and Reporting Formats,* ORNL/CON-337 *(Oak* Ridge, TN: Oak Ridge National Laboratory, October 1991).

conservation implies an overall reduction in electricity use and energy services, many industry analysts prefer to use the more neutral and inclusive term *energy efficiency*. Energy conservation measures can be included in efficiency programs.

Demand-side management (DSM) programs are organized utility activities intended to affect the amount and timing of customer electricity use. In theory, successful DSM programs can reduce the need to build powerplants by controlling demand for electricity and thereby creating room for expansion without providing additional supply resources.

Utility load management programs are closely related to energy efficiency DSM programs. Load management programs refer to utility programs intended to influence customer demand through economic or technical measures usually with the objectives of reducing demand during peak periods, and/or encouraging demand during off-peak periods).[2] In pursuit of the frost goal, load management programs can include many of the same technologies and measures used for overall reductions in electricity use. Load management programs usually employ a combination of load management incentives, metering to measure the time and quantity of customer electricity use, and load control equipment. Because of the time-shifting aspect of load management programs, they may be targeted at peak loads and not necessarily at an overall reduction in electricity consumption. Load management programs can also be directed at retaining load or customers, and expanding customer loads. Box 5-A shows common utility load management strategies and their load shape objectives. These same load shape objectives are used for utility DSM programs.

Electric utilities have used load control measures for more than 50 years, but interest in these measures increased significantly in the 1970s and 1980s. Over this period, interest in load control was high among utilities that purchase most of their power from others (primarily municipal utilities and rural cooperatives) because load control offered an additional means to reduce wholesale power costs.[3]

Utilities can have many goals for DSM and load management programs. Maximizing energy savings is one. Others, and perhaps more important to different utilities, are maximizing customer satisfaction, minimizing lost revenues (utility revenues lost when consumers reduce electricity use), mininizing free riders, or minimizing the cost per kilowatt (kW) or kilowatt-hour (kWh) saved.

The development of utility energy efficiency programs coincides with the trend toward adoption of integrated resource planning (IRP) processes by electric utilities. IRP involves a comprehensive and open utility planning process that includes greater consideration of potential demand-side measures on a par with generation and other supply-side additions in order to meet projected loads. The prospect of greater reliance on demand-side measures to delay the need for new powerplant construction requires that potential energy savings be estimated with greater certainty and that actual savings be validated. Adoption of IRP has created new challenges for electric utilities planners and their regulators in incorporating rapidly expanding DSM programs into the resource mix.

INFLUENCING CUSTOMER BEHAVIOR

Electric utilities, with the approval and encouragement of State regulatory bodies, have adopted a variety of mechanisms to influence customer electricity use: load controls, differential or incentive rates, rebates, loans, grants, shared-savings agreements, energy audits, technical as-

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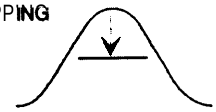
[2] U.S. Congress, Office of Technology Assessment New *Electric Power Technologies: Problems and Prospects for the 1990s, OTA-E-246* (Washington, DC: U.S. Government Printing Office, July *1985)*, p. 142.

[3] Ibid., p. 148.

Box 5-A-Load Shape Objectives

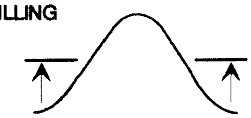
PEAK CLIPPING, or the reduction of the system peak loads, embodies one of the classic forms of bad management. Peak dipping is generally considered as the reduction of peak bad by using direct bad control. Direct load control is most commonly practiced by direct utility control of customers' appliances. While many utilities consider this as a means to reduce peaking capacity or capacity purchases and consider control only during the most probable days of system peak, direct load control can be used to reduce operating cost **and** dependence on critical fuels by economic dispatch.

PEAK
CLIPPING



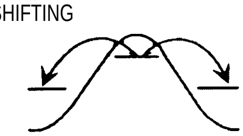
VALLEY FILLING is the second classic form of bad management. Valley filling encompasses building off-peak loads. This may be particularly desirable where the brig-run incremental cost is less than the average price of electricity. Adding properly priced off-peak bad under those circumstances decreases the average price, Valley filling can be accomplished in several ways, one of the most popular of which is new thermal energy storage (water heating and/or space heating) that displaces loads served by fossil fuels.

VALLEY
FILLING



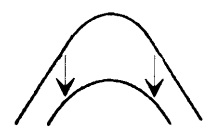
LOAD SHIFTING is the last classic form of load management. This involves shifting load from on-peak to off-peak periods. Popular applications include use of storage water heating, storage space heating, coolness storage, and customer load shifts. In this case, the bad shift from storage devices involves displacing what would have been conventional appliances served by electricity.

LOAD
SHIFTING



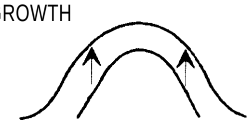
STRATEGIC CONSERVATION is the load shape change that results from utility-stimulated programs directed at end-use consumption. Not normally considered load management, the change reflects a modification of the bad shape involving a reduction in sales as well as a change in the pattern of use. In employing energy conservation, the utility planner must consider what conservation actions would occur naturally and then evaluate the cost effectiveness of possible intended utility programs to accelerate or stimulate those actions. Examples include weatherization and appliance efficiency improvement.

STRATEGIC
CONSERVATION



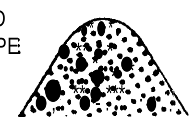
STRATEGIC LOAD GROWTH is the bad shape change that **refers to a general increase** in sales beyond the valley filling described previously. Load growth **may involve increased** market share of loads that are, or can be, served by competing fuels, as well as area development. in the future, load growth may include electrification. Electrification is the term currently being employed to describe the new emerging electric technologies surrounding electric vehicles, industrial process heating, and automation. These have a potential for increasing the electric energy intensity of the U.S. industrial sector. This rise m **intensity maybe motivated by reduction in the use of fossil fuels and raw materials resulting** in improved overall productivity.

STRATEGIC
LOAD
GROWTH



FLEXIBLE LOAD SHAPE is a concept related to reliability, a planning constraint. Once the anticipated load shape, including demand-side activities, is forecast over the corporate planning horizon, the power supply planner studies the final optimum supply-side options. Among the many criteria used is reliability, Load shape can be flexible-if customers are presented with options as to the variations **in quality of service that** they are willing to allow in exchange for various incentives. The programs involved can be variations of interruptible or curtailable bad; concepts of pooled, integrated energy management systems; or individual customer **load** control **devices offering service** constraints.

FLEXIBLE
LOAD
SHAPE



SOURCE: U.S. Congress, Office of Technology Assessment, 1993, adapted from Battalle-Columbus Division *and Synergic* Resources Corp., Demand-Side Management, Volume 3:Technology Alternatives and Market Impkmmntatkm Methods, **EPRI EAVEM-3597 (Palo Alto, CA: Electric Power Research Institute, 1984).**

sistance, **direct** equipment installation and replacement, comprehensive energy management programs, and so forth. Many of these programs are of recent vintage and limited in scope, but overall the initial savings have been promising even though not as high as expected. Certain issues have recurred in the design, implementation, and evaluation of these programs, including: cost-effectiveness determinations, choice of effectiveness tests, free riders, measurement of savings, persistence of savings, customer participation rates, utility cost recovery, and financial incentives.

All utility DSM programs fit into one or both of the following programs: 1) those affecting the way energy-using equipment is operated, and 2) those that focus on the installation of efficient technologies. Utilities typically operate separate programs for commercial, residential, and industrial customers.

Load control measures differ based on the degree of control and input exercised by the utility and the customer. They range from programs in which the utility asks customers to reduce load and the customer individually decides which appliances to turn off, to direct load control systems that are highly automated and have little customer input.

Direct control systems are by far the most common form of load control. They typically consist of a communications system that links the customer's equipment with the utility and a decision logic system (i.e., a computer program) that dispatches commands to the customer equipment in response to information on utility and/or customer loads. In a residential load management program, equipment might be installed to allow the utility to cycle participating home air-conditioners and water heaters on and off briefly during times of peak load with little or no disruption to the customer. With widespread participation, this represents a critical strategic tool for utilities to shave peak load. Typically the customer enters into an agreement with the utility that gives them either lower rates and/or a small monthly payment for participation in the program. For example, Potomac Electric Power Company (PEPCO) offers a credit of $110 to households that join its "Kilowatchers Plus Club" and allow the company to shutoff their air conditioning for short periods of time to offset summer peak loads if needed. Some 100,000 members of PEPCO'S "Kilowatchers Club" receive a $45 credit for allowing the utility to cycle their compressors off and on for brief periods. PEPCO estimates that by 1995, cycling will pare 170 megawatts from its summer loads.[4]

Utilities and regulators have experimented with various incentive **rates in an** attempt to encourage greater efficiency in electricity use. They have instituted variations in rates by charging more for peak load and higher volume usage to reflect the increased costs of providing such service. There has been a great deal of activity involving time of use rates for large industrial and commercial customers, but only limited experience with time of use rates for residential customers. Participation in time of use rates generally requires installation of meters that allow measurement of both the quantity and time of customer electricity use.

Information programs are intended to alert customers about potential electricity savings measures. Examples include informational advertising campaigns, energy audits, and bill enclosures. According to an analysis of utility DSM programs prepared by the American Council for an Energy-Efficient Economy (ACEEE) for New York State, information-only programs that provide customers with general information about energy efficiency opportunities and/or combine information with energy audits have low participation rates

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[4] "Utilities Field Peak Power Demand with Incentives for Homeowners," *Wall Street Journal*, June 6, 1991, p. Al.

and low energy savings[5] The most effective are the free energy audits coupled with post-audit followup. According to ACEEE, the programs can achieve high participation rates (60 to 90 percent) and energy savings among participating customers of 6 to 8 percent.[6] Revamped information programs are reported to be achieving greater levels of participation.

Rebate programs provide money to customers, contractors, homebuilders, vendors, or others who make equipment choices to help defray some or all of the cost of DSM measures. Rebate programs are the most *common* utility program offered. The form of rebate mechanism can be cash, discount coupons, or bill credits. ACEEE found that the most successful rebate programs in their survey reached about 10 percent of eligible customers (and about 25 percent of the larger customers with peak demand of 100 to 500 kW) over a period of 3 to 7 years. The most successful programs cut electricity use by 5 percent at utility costs of $0.01/kWh saved. The most effective targets have been lighting and heating, ventilation, and air conditioning (HVAC) equipment improvements. Rebate programs have not historically been very effective at promoting system improvements-those involving the interaction of many pieces of equipment. Generally, participation levels are moderate, as are energy savings. They effectively cut utility peak demand and electricity sales by about 1 percent/year in successful cases surveyed in the ACEEE study. Some analyses indicate that participation drops off after several years of aggressive program promotion; however, more analysis is needed of this possible pattern according to ACEEE'S study.

The "Super Good Cents" Program, sponsored by the Bonneville Power Administration and northwestern utilities, provides certification for new residential buildings and manufactured homes that meet stringent energy efficiency standards. The program qualifies the buyers for rebates from participating utilities.

Loan programs provide cash to finance energy-savings investments and are attractive for customers who lack cash. The program may allow the customer to repay energy efficiency investments on the monthly utility bill, often at a low interest rate. They are offered by only a few utilities. Studies of consumer loan programs found that customers offered a choice of rebates or low-interest loans have generally opted for the rebates.[7]

Increasingly, utility programs bundle various DSM approaches into a single package. For example, the City of Fort Collins Light and Power offers residents of Fort Collins the Energy Score Home Energy Rating Service that combines information, audit, building efficiency standards, rebates, loans, and eligibility for energy efficient

5 American Council for an Energy Efficient Economy, *Lessons Learned: A Review of Utility Experience with Conservation and Load Management Programs for Commercial and Industrial Customers* Final Report, Energy Authority Report 90-8 (New York, NY: New York State Energy Research and Development Administration, April 1990). Hereinafter referred to as Lessons *Learned. This report* provides an analysis of utility industrial and commercial conservation and load management programs, including energy-savings, participation rates, costs, etc. The analysis covered some 200 utility commercial and industrial programs from 58 utilities and was based on comprehensive surveys and interview conducted circa 1987.

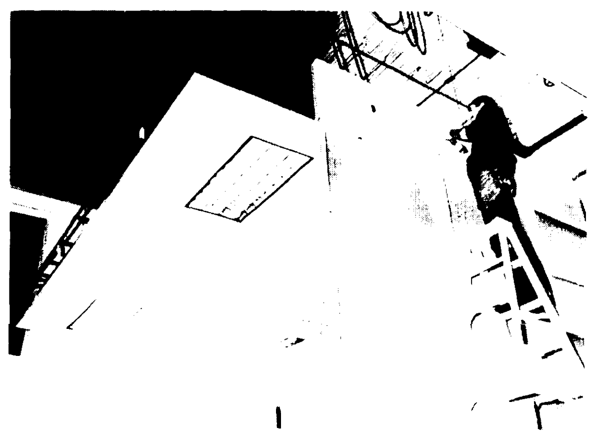
6 Ibid.

7 *Lessons Learned*, supra note 5, p. 5-5.

mortages. Homeowners, builders, sellers, or purchasers of new or existing homes can contact an independent utility-certified rater to inspect and report on a home. The rater provides a comprehensive home energy efficiency analysis covering the orientation of the lot, insulation, windows, doors, air leakage, heating and hot water systems, and other factors influencing energy use. The house is given a rating from O to 100, with 100 being the most efficient. The cost of the rating is $100 to $175 and the city utility picks up $50 of the cost. Homes with higher energy efficiency ratings (G-70 for gas-heated homes, and G-65 for electric heated homes) may be eligible for a 2 percent ratio increase on an energy efficient mortgage from participating lenders, increasing the purchaser's buying power. The rating also identifies opportunities for efficiency improvements and may qualify the homeowner for the utility's zero-interest "Zilch" home improvement loan to finance the upgrades.

Performance contracting programs offer payments based on the amount of energy saved as a result of efficiency improvements. They generally rely on energy service companies (ESCOS) or other vendors to recommend, install, and finance efficiency measures. Utilities can also contract directly with large customers. According to the ACEEE study, the most successful of these programs have included high incentives, but have achieved significant savings. On the whole these programs have been more costly than some other types of programs. Experience has indicated that ESCOS have tended to focus on the largest customers and the most lucrative measures (especially lighting and cogeneration) to achieve savings. ESCO contracts provide one mechanism for reaching some of the most cost-effective, energy-efficient opportunities with significant economies of scale. Other approaches can target and achieve these same savings opportunities. Initial experience with performance contracting and ESCOS has been mixed. Many utilities are substantially revising their performance contracting programs or are complementing them with other types of programs. Performance contracting with ESCOs or with large customers still remains an attractive alternative for financing and installing energy-saving technologies.

Comprehensive programs combine regular personal contacts with customers, comprehensive site-specific technical assistance, and financial incentives that pay the majority of the installation costs of efficiency measures. According to the ACEEE study, these programs were highly successful, but also tended to be among the most expensive at a typical cost of $0.03/kwh saved. There is little experience with large-scale programs over time. The analysis suggests that this type of program maybe particularly appropriate for serving small customers and for new construction (where there is a one-time opportunity to capture substantial savings at only the marginal cost of efficient equipment over standard equipment).



NICK CHRISTMAS, BPA

Lighting Design Lab in Seattle. This resource center is supported by a consortium of Federal and State agencies, electric utilities, and conservation groups. It aids commercial designers, architects, engineers, contractors, facilities managers, and others in the design and selection of efficient lighting applications.

Request **for proposal** (RFP) and bidding programs have been in operation for several years. Under these programs, the utility issues a request for proposals to provide demand-side resources and receives and evaluates proposals from ESCOS and customers. After evaluating the bids, the utility negotiates contracts with the winning bidders for specific energy savings and load reductions. Based on preliminary results analyzed for the ACEEE New York study, these programs offer the promise of significant savings (up to 1.5 percent of peak demand after 2 years). The success has been tied to reaching large customers directly or through ESCOS who participate in the process. The programs generally are less than utility avoided cost, but a tendency has been noted for bids to approach utility avoided costs. Much of the initial experience with DSM bidding programs was in Maine and New York. As utility competitive resource procurements have expanded, so too have the number of bidders offering demand-side installations. Moreover, these demand-side bids are proving to have a higher success rate in winning bids than conventional supply options.[8]

Fuel switching programs involve incentives to utility customers to reduce load by switching to an alternative energy source for all or some of the service provided by electricity. Examples include the installation of a gas-powered air conditioning system in a large commercial office complex or switching from an electric resistance to a gas water heater. Fuel switching and electrification measures generally involve complicated site-specific tradeoffs, and no generalizations can as yet be made about their overall performances and costs.

MEASURING ENERGY SAVINGS AND EVALUATING EFFECTIVENESS

There has been over a decade of experience with utility load management and DSM programs around the country. Substantial dollar and energy savings have been claimed, but much remains to be learned.

To be successful from the perspective of least-cost planning objectives, the program should achieve maximum long-term, cost-effective net energy and demand savings (net of what would be required in absence of the utility program). Generally this means a long-term strategy aimed at serving the most customers (including all but the very smallest). This is to assure maximum savings and to minimize equity issues of cross-subsidization. In addition, the strategy should promote efficiency/load management measures that customers are unlikely to install without utility efforts in the short term and for longer-term measures with long-Lives or that have a high probability of replacement.

The ACEEE study found that utility DSM programs as a whole had not yet had a dramatic impact. The programs surveyed were reaching less than 5 percent of target customers on a cumulative basis and were reducing their energy use by less than 10 percent. As of 1989-90, it was estimated that utility peak demand had been reduced by less than 1 percent. They did find a number of highly successful programs, however. A few reached 70 percent or more of eligible customers—with customer energy savings of 10 to 30 percent, and reductions in utility peak demand of up to 5 percent. Many of the most successful programs, however, were still in pilot- or small-scale programs and had yet to be applied on a large-scale basis. The good news is that all of the energy savings reported came at a cost to utilities of less than $0.04/kWh saved even including free riders. These reported costs were less than many utilities' avoided costs to generate new power, making it likely that the programs would prove cost-effective using the utility cost test.[9]

Since the ACEEE study was published, utility DSM programs have continued to grow, and many utilities are now projecting significant savings from their efforts. A recent analysis by

[8] See discussion of bidding programs in ch. 6.

[9] Cost-effectiveness tests are described in ch. 6 of this report.

Oak Ridge National Laboratory, based on reports to the Energy Information Administration, found that existing utility programs are projected to offset 14 percent of the growth in electricity demand by the year 2000.[10]

Measuring Swings

The savings from a DSM program are estimated by comparing energy demand both before and after the program is implemented. Evaluating the success of utility DSM programs is difficult both on a local and a national basis. Most savings estimates reflect engineering estimates, and more sophisticated measured and validated **estimates of savings are rare.** Engineering estimates generally rely on simple rules of thumb calculations using manufacturers data, or engineering simulations. Engineering **estimates can** be fairly accurate for some simple DSM actions (e.g., domestic water heater wraps). However, in practice, engineering estimates have been found **to overestimate** actual electricity savings.[11] As experience with DSM programs increases, and energy savings are subjected to more rigorous impact evaluation, it should be possible to develop other techniques, or at least more accurate engineering rules of thumb, to support reliance on this technique to estimate potential savings. Until then, such estimates should be viewed with caution.

In order to show the effectiveness of efficiency measures, it must be determined how much electricity use is actually reduced over what it would be in the absence of the measure. Depending on the goal of the program, monitoring usage by the time of use (on-peak vs. off-peak) will also be important to determine impacts on load shape.

There are several means of measuring (collecting data on) electricity use and the impacts of efficiency improvements: monthly customer bills, spot metering (either on a short-term before and after retrofit or permanent basis), whole building load research monitoring, and end-use load research monitoring. See box 5-B.

Measuring exact savings is not necessary in all cases and could become prohibitively complex as the number and extent of DSM programs increase. For simple measures, where there is substantial experience (more efficient residential refrigerators, for example), past measurements and engineering estimates may suffice to calculate savings for the program. For more complex and site-specific DSM measures (e.g., retrofitting and relamping a large commercial building), detailed site-specific measurements of specific load shapes may be needed to estimate savings.

Comparison of customer billing data is the most straightforward and least expensive method for many applications, but is not adequate for new construction or for large and complex installations. In the former case, bill data will be absent, thus engineering calculations or comparisons with similar buildings for which data are available might be used. In the latter case, normal fluctuations in energy use could mask the effects of efficiency improvements and so specific end-use metering that tracks the time and quantity of electricity may be required.

Once total end-use savings have been determined, the impacts on utility load shape and supply must be calculated. In general, because of transmission and distribution losses, the actual kilowatts saved at the powerplant from customer efficiency measures are about 8 percent higher than that saved on site. Kilowatts saved by the customer may also reduce utility reserve margins, i.e., customer savings plus the reserve margin percentage (allowance for powerplant down-

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lo Eric Hirst, *Electric Utility DSM-Program Costs and Effects: 1991-2001,* ORNL/CON-364 (Oak Ridge, TN: Oak Ridge National Laboratory, May 1993).

11 S.M. Nadel and K.M. Keating, ''Engineering Estimates vs. Impact Evaluation Results: How Do They Compare and why,' *Energy Program Evaluation: Uses, Methods, and Results,* Proceedings of the 1991 International Energy Program Evaluation Conference, CONF-91OSO7, August 1991, cited in Hirst and Sabo, supra note 1, pp. 24-33.

Box 5-B-Methods Used to Measure Electricity Consumption

Approach	Explanation	Advantages	Disadvantages
Monthly electricity bills	Obtain electrtcity bills for a year before and a year after participation, adjust annual electricity use for weather and other relevant factors, and compute the difference between pre- and post-participation use in kWh/year.	Measures actual changes in electricity use, permits adjustment for changews in weather and other factors, and requires little primary data collection.	Provides no estimate of demand (kW) reductions unless customers face demand charges. Analysis of monthly billing data can yield ambiguous results. Estimates of kWh savings affected by changes in facility use unrelated to devices installed.
spot metering of electricity use	Monitor electricity use before and after participation for short times (e.g., a few days); also measure other relevant factors (e.g., operating hours for equipment and heating degree days) for a longer time (e.g., up to a year).	Measures electricitysavings (both kWh and kW) for well-defined, short time periods. Modest cost.	Could yield estimates of savings not realized if measurernents taken incorrectly or at atypical times, or if building use changes. Difficult to apply to devioes that are season-or weather-dependent.
whole-building load-research monitoring	Monitor electrlcity use of facility to record kW *demand use* before and after participation.	Measures actual electricity and demand (kWh and kW), Can be combined with other data to adjust for changes in weather and factors.	Expensive and time consuming. Large amounts of data produced. Results may be affected by changes in facili ment installed.
End-use, load-research monitoring	Monitor specific circuits affected by new systems to record kW demand before and after participation.	Measures actual electricity use and demand (kWh and kW) for specific end uses affected by program. Can be combined with other data to adjust for changes in weather and other factors.	Most expensive and time consuming method. Large amounts ofdata require sophisticated computer programs and analysts to interpret. Results may be affected by changes in facility use unrelated to equipment installed.

SOURCE: Eric Hlrst and Carol Sabo, Electric Utility DSM *Programs: Terminology and Reporting Formats,ORNL/CON-7(Oak Ridge,* TN: Oak Ridge National laboratory, October 1991), p. 36.

time). Improved measurement and monitoring of end-use efficiency savings and documentation of actual reductions in utility-generating demand over time may contribute to less uncertainty about demand-side measures in utility resource planning.

Tracking the persistence of energy savings from efficiency measures is also important. Some measures may prove to be fairly reliable and long-lived (for example building insulation that the customer is unlikely to remove). But other measures may be affected by declines in the technical performance of equipment, the lifetime of the measure, user replacement of measures when they wear out, changes in operating conditions induced by the DSM program, or market-related changes in electricity use.[12] The energy-savings benefits of a compact fluorescent light may disappear, if when it is worn out, the user replaces it with a standard incandescent lamp. Similarly, an occupant might be induced to raise thermostat settings to take advantage of improved building insulation or an efficient space heating system, thus, at least partially offsetting the efficiency gain. This phenomenon of losses in efficiency gains because of customer behavior is often referred to as takeback.

Participation Rates

The success of DSM programs often hinges on the number of customers and/or trade allies (businesses that sell or influence choices of energy using equipment such as architects, designers, builders, appliance dealers) that participate in the program. Participation rates are the ratio of the number of participants to the number of eligible customers. In many cases, determination of the pool of potential participants is fairly straightforward and based on information a utility readily has at hand (e.g., commercial office buildings, all residential customers). However, for more specialized programs, additional market research may be needed to identify potential participants, for example, homes with electric resistance heat, or industrial motor applications.

As a practical matter, most estimates of DSM program participation rates generally include free riders. Free riders are customers who participate in a program, but would have undertaken the same conservation actions even if the program were not offered.[13] (Some discussions also brand as free riders ratepayers who benefit from conservation programs, but do not participate; however in this report we include only program participants.) The presence of free riders tends to overstate program results. Some economists maintain that free riders should not be eligible for program incentives and will drive up program costs and ratepayer impacts to an unacceptable degree.[14]

The presence of free riders, setting aside the issue of whether they should be eligible for financial incentives, complicates evaluations of the effectiveness of utility DSM programs. In determining g whether the program has actually had an impact on customer energy use, the focus must be on net savings-calculated by determining the share of free ridership and excluding the associated savings.

But the presence of a high portion of free riders in a program is not necessarily an indication that the program is not effective for several reasons.

First, one should expect a high degree of free riders early in the program and then as the program becomes more successful and participation increases, the free rider share should approach a floor defined by the penetration of the efficiency measure in the market place or the market share of efficient devices versus standard devices in absence of the program.[15]

Second, many estimates of free ridership are based on self-identification by those who say they would have adopted the measure anyway, thus tending to overestimate actual free ridership. The bias problems with surveys are well documented and show a tendency of respondents to give the perceived "right" answer to the interviewer

12 Hirst and Sabo, supra note 1, p. 34.

13 Ibid.

14 Conversely, another complication is the general exclusion from participation rates of free drivers. Free drivers are customers who take DSM program-recommended actions, but do not participate directly in the program (i.e., claim rebates). The absence of free drivers will result in understating the program's effectiveness.

15 *Lessons Learned*, supra note 5, pp. 86, 167.170, (various utility programs estimated free riders at 5 to lo percent for replacement Of working motors and 5 to 35 percent for new motors).

rather than the ''true' answer. Additionally, while a participant might be favorably disposed to installation of the efficiency measure in the absence of the program, it is difficult to estimate with any accuracy how many of the self-identified free riders would actually have installed the measure without the program or the extent to which the existence of the program accelerated their actions.

Costs of DSM Programs

Monitoring and estimating the costs to utilities and customers is necessary to determine whether the costs of efficiency programs are outweighed by their benefits, and to provide for adequate cost recovery in regulatory proceedings.

For newly authorized programs, very little actual cost data may be available, but as experience increases, costs should be calculated with greater accuracy. The ACEEE review of 58 existing utility DSM programs found that reported cost figures per kilowatt and kilowatt-hour for efficiency measures were only approximate, and often ignored customer costs, and sometimes relying on rough estimates of indirect utility costs. The lack of accurate cost data is troubling when one considers that over $2 billion was invested in utility energy efficiency programs in 1991 and that by the end of the decade some experts estimate that DSM could be a $30 billion/year industry.[16] Moreover, more reliable and detailed cost data are needed for DSM resources to be more fully integrated into utility resource planning processes.

Determining Cost-Effectiveness

There is a wide variation in how different utilities and State regulators calculate the cost-effectiveness and costs of DSM programs. The cost-effectiveness of DSM measures is commonly estimated from either the utility, customer, or the societal perspective. For more on cost-effectiveness tests, see chapter 6 of this report.

The utility perspective considers the utility's costs and benefits for program, including rebate and other costs, avoided energy and capacity benefits. It excludes customer costs and the value of revenues lost by the utility because of energy savings.

The total resource cost perspective (adopted in New York State) includes money paid by program participants for materials, installation, and maintenance (including credits for reducing customer costs, such as reduced maintenance costs in addition to factors considered from the utility perspective). In practice, the total resource cost test suffers from the fact that extensive data on customer costs are not generally collected by utilities.

There are several alternative units used in estimating cost-effectiveness. Cost per kilowatt-hour saved simply uses program expenses divided by kilowatt-hours saved). Other measures calculate levelized cost per kWh saved (discounting the cost over time) to provide a long-term cost estimate. More rigorous approaches involve calculation of total levelized costs of the program and comparison with avoided total costs of the energy saved (avoided energy costs plus levelized value of annual capacity cost divided by 8,760 hours/year).

Evaluation of DSM Programs

Evaluation is the systematic measurement of the operations and performance of DSM programs and should rely to the extent possible on objective measurements and well-defined and executed research methods. Program and impact evaluations of DSM and load management programs are critical components of both utility and government assessments of the cost-effectiveness and success of efficiency measures. Program evaluation is a rapidly evolving specialty that

16 Eric Hirst and Jolm Reed (Eds.), *Handbook of Evaluation of Utility DSM Programs,* ORNL/CON-336 *(Oak* Ridge, TN: Oak Ridge National Laboratory, December 1991).

relies on social-science research methods and technical data to provide valid and reliable documentation and quantification of program results and costs and to analyze their usefulness. Good impact evaluation efforts are not cheap or easy to perform, and yet are an indispensable element of any expansion of efficiency programs. Adequate funding of evaluation and monitoring can amount to 10 percent of the costs of utility programs. As the costs, extent, and expectations of utility energy efficiency programs grow, the resources devoted to monitoring and evaluation will have to expand and the evaluation techniques must also become more technically sophisticated and reliable.

MIXED RESULTS FROM UTILITY ENERGY EFFICIENCY PROGRAMS

While there are clearly successful utility energy efficiency programs with demonstrable energy savings, experience so far indicates that the energy savings achieved fall far short of the full technical potential that is cost-effective to end users.

The ACEEE review of 58 utility programs found evidence for this conclusion in low participation rates and in actual savings well below cost-effective technical potential.[17] programs with the highest participation rates reached only 10 to 70 percent of eligible customers. Among participating customers, the programs with the highest energy savings were found to yield only 20 to 60 percent of the cost-effective technical potential. Cost-effective technical potential was defined as measures having equipment and installation costs less than $0.05 kWh saved, i.e., less than the retail commercial and industrial electricity rates and/or utilities' long-run avoided costs. The gap between technical potential and actual savings was large for the best programs and larger still for typical programs.

Low participation and savings rates are typical of the startup stage of most programs, and many programs were still limited in scale and had only a few years experience. However, other utility programs have been operating for some time and it is reasonable to expect better performance.

No utility operates state-of-the-art programs in all areas. The largest commercial and industrial efficiency programs were found to have reduced kilowatt-hour sales by only 2 to 14 percent-far less than the estimated 35 percent cost-effective savings potential (from the consumer perspective) found in the ACEEE study of New York State potential.[18] These performance shortfalls raise questions about the viability of ambitious State and utility efficiency goals.

Some economic analysts are challenging utilities and regulators cost-benefit equations and questioning the claimed successes of DSM programs. One controversial analysis performed for the U.S. Environmental Protection Agency discarded the more commonly used cost-benefit tests and applied an alternative cost-benefit measure to DSM program savings calculated by two utilities. The report examined a total of 16 separate DSM programs operated by the two utilities and concluded that none of the programs passed its ''conventional' economic cost-benefit test if environmental benefits were excluded from the calculations .19

The New York State Energy Plan sets a goal for utility conservation and load management programs to reduce electricity use and demand by 15

17 *Lessons Learned*, supra note 5, pp. 181-196.

18 American Council for an Energy-Efficient Economy, and the *New York* State Energy Office, *The Achievable Conservation Potential in New York State from Utility Demand-Side Management Programs,* Energy Authority Report 90-18 (Albany, NY: New York State Energy Research and Development Administration, November 1990).

19 Albert L. Nichols, *Estimating* the *Net Benefits of Demand-Side Management Programs Based on Limited Information*, (Cambridge, MA: National Economic Research Associates, Inc., Jan. 25, 1993), p, 34, cited in Kennedy Maize and John McCaughey, "DSM at Mid-Passage: A Discussion of the State of the Art and Science of Demand-Side Management in Electric Utilities,' *The Quad Report, Special* Report, Spring 1993.

percent by 2008. To do this, ACEEE estimates that DSM programs will have to reach 50 to 70 percent of customers and achieve savings among participants of 20 to 30 percent.

Nevertheless, many utilities have now enthusiastically embraced DSM programs. The New England Electric System (NEES) has been an early leader in utility DSM programs, spurred in part by financial incentives adopted by State regulators in Massachusetts, New Hampshire and Rhode Island. For 1990, NEES reported that potential system profits from DSM programs were $10 million. Estimated savings were a total of 194,300 megawatt-hours saved and 116.5 megawatts of demand reduced.[20]

NEES'S third resource plan adopted in 1991 relies on DSM programs to displace a total of 850 megawatts by 2000, constituting more than 12 percent of the utility's capacity resources. NEES resource plan will also achieve a 45 percent reduction in net air emissions by 2000 through its resource strategies including DSM, converting/ repowering an existing plant to natural gas, accelerating environmental compliance, power purchases from nonutility generators and Canadian hydroelectric facilities, and various initiatives to offset greenhouse gas emissions.[21]

Pacific Gas & Electric Company, the Nation's largest utility, also has long experience in DSM programs. PG&E plans to spend about $2 billion on customer energy efficiency in the 1990s and cut their energy growth by half and peak demand by 75 percent (2,500 megawatts). PG&E projects that these savings can be achieved at a cost of from $0.03 to $0.04/kilowatt-hour-less than half the cost of building new fossil generation.[22]

Elements of Successful Programs

Even though no utility was found to perform at state-of-the-art levels in all of its efficiency programs, a number had demonstrated notable success.[23] They shared certain program elements that are believed to contribute to above-average participation and savings:

- *Marketing strategies that use multiple approaches (direct mail, media, etc.) combined with personal contacts with the target audience.* Particularly successful are those that develop regular, person-to-person contacts and followup contacts after installation to assure that the measures are working properly and to promote additional measures.
- *Targeting of program approaches and marketing strategies to different audiences* (customers, architects, equipment dealers, engineers, developers) and for different types of investment decisions (new construction, remodeling, replacement, retrofitting). Including target audiences in program design is especially successful in producing a program that meets consumer needs.
- *Technical assistance to help targeted customers assess efficiency opportunities and identify and implement DSM measures.* Assistance might include energy audits, advice on equipment, contractors, computer modeling of possible savings alternatives, information on new state-of-the-art technologies. Detailed technical assistance is generally only cost-effective when coupled with incentive programs that induce high levels of customer participation and savings.
- *Simple program procedures and materials that make it easier for the customer to*

20 Association of Demand-Side Management Professionals, 'NEES Credits Regulatory Incentives In 'Overwhelming' 1990 DSM Success,'' *Strategies,* vol. 2, No. 2, Spring 1991.

21 ''New England Utility Outlines Plans to Cut Greenhouse Emissions by 4570, " *Energy Conservation Digest, Dec. 23,* 1991, p.1.

22 Hirst and Sabo, supra note 1, p. 1.

23 Reviews of utility efficiency and conservation programs indicate that some utilities consistently do a better job than others in operating these programs. Among the most successful cited in the 1990 ACEEE study were: the City of Palo Alto, CA; Central Maine Power; New England Electric System; Pacific Gas and Electric; Southern California Edison; and Wisconsin Electric. See Lessons *Learned,* supra note 5.

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An energy audit team makes a site visit to a Pacific Northwest lumber mill to study operations to help development of an industrial energy efficiency program.

understand program potential and to participate. Examples are one-step application procedures, assistance in filling out forms, packaged rebate programs.

- *Financial incentives that attract customer attention and reduce first costs of implementin,q DSM measures.* Analyses of the effects of varying incentive rates are scanty. But initial results indicate that offering free measures produces the highest participation rate. High incentives (50 percent or more of a measure cost) generally appear to produce higher participation rates than moderate incentives (one-third of a measure's cost). Moderate incentives may not produce higher participation rates than low incentives, however.
- *Multiple measures available for customers to choose from that increase the likelihood that customers will find a measure or program that is appropriate for their needs and/or to implement more than one measure and gain more savings.* There are a plethora of programs limited solely to lamps and air conditioners, Including additional HVAC, efficient lighting, and motor measures and allowing customers to propose their own qualifying measures tend to boost participation rates and savings,
- *Programs promoting new technologies not yet widely adopted in the marketplace, These* programs for high-efficiency technologies tend to reduce free riders and achieve higher savings than available through first generation technologies. A high percentage of free riders (about 30 percent) have been found with <time technologies, especially when rebates are provided for products that are already being purchased by many customers, such as, reduced wattage lamps and moder-

ate efficiency air conditioners. Because customers may be unfamiliar with and wary of new, advanced energy-saving technologies, programs that focus on them may require substantial marketing efforts to boost typical low initial participation rates.

Additional factors that contributed to the success of utility DSM programs were: top management commitment to energy efficiency measures, staff and organizational commitment, skills, support, creativity, and flexibility. Personal contact marketing and followup by utility personnel are also key to successful programs. Lastly, the most successful utility programs have been those where utilities are offered incentives for successful programs.

Problem Areas

The ACEEE study identified several problem areas that must be addressed if DSM programs are to have a significant effect.

Most utility commercial and industrial DSM programs have had only a limited focus. The programs must expand beyond lighting and small HVAC improvements to include advanced lighting and motor technologies and comprehensive industrial system improvements. There is no one-size-fits-all comprehensive demand-side program. Regulators and utilities must develop packages of programs tailored for the utility, load, and customer characteristics if the initiative is to be a success. Many utilities in an effort to structure their services to enhance customer values are examining ways to provide more comprehensive energy efficiency services,

Participation rates have been low. Marketing efforts must be expanded to reach and persuade more customers to participate.

More data and research are needed to support DSM program development and evaluation. Program design and evaluation is hampered by the lack of credible data on energy use and target populations (building characteristics, motors and other equipment), and by the lack of accessible and useful documentation and evaluation of existing programs. Information on actual percentage reductions in energy use is rarely collected and yet would be of invaluable assistance to utilities, regulators, and consumers.

Additionally, because energy and load management efforts have been limited in scope and long-term experience is lacking, mistakes will be made. But utilities may fear to publicize mistakes and shortcomings for fear that regulators will punish them. There is, however, much to be learned from mistakes. Therefore unsuccessful program experiences should be investigated and the results publicized so that others might avoid these pitfalls.

Need for Complementary State and Federal Efforts

Even the best DSM programs cannot achieve all the cost-effective savings. Some customers won't participate, no matter what incentives utilities offer. Many will not adopt all cost-effective measures. Because of this tendency, utility programs need complementary approaches--e.g., building codes and appliance and equipment efficiency standards-in order to maximize the overall adoption of energy-efficient technologies. The California Energy Commission analysis of the effectiveness of utility DSM measures in 1983 found the reduced peak demand of 2,718 megawatts was due 45 percent to utility programs, 37 percent to building code requirements, and 16 percent to various appliance efficiency standards.[24] Federal and State efficiency initiatives can also boost the availability of energy efficiency products in the marketplace. See chapters 6 and 7 for discussion of these efforts.

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[24] California Energy Coremission, Conservation *Report* (Sacramento, CA: 1986), p. II-11.

INCORPORATING ENERGY EFFICIENCY INTO UTILITY OPERATIONS-THE ROLE OF IRP

IRP has become the main process through which utilities incorporate DSM measures into their mid-and long-term resource planning. As a planning tool, IRP allows a utility to incorporate a variety of information about load, system characteristics, demand growth, resource options, and corporate goals into an analysis that explicitly evaluates supply- and demand-side resources in a consistent manner and expressly confronts the uncertainties inherent in utility planning to produce a flexible resource plan for meeting customer needs at least-cost. IRP also generally includes opportunities for public involvement and regulatory review, as well as consideration of environmental and other social impacts of utility resource alternatives.

By mid-1993 utilities in at least 41 States were actively involved in some sort of IRP process. At least 33 States require IRP or least-cost planning by their utilities. Under Federal law, utilities that purchase power from the Bonneville Power Administration, the Western Area Power Administration, and the Tennessee Valley Authority also must adopt IRP planning principles as a condition of their power contracts. Information on State and Federal IRP initiatives may be found in chapters 6 and 7 of this report.

Resource planning is an integral part of utility operations and is driven by the three fundamental goals-serving customer load reliably, minimizing customer costs, and maintaining the financial stability of the utility (see chapter 3). Today's IRP process evolved from traditional utility planning, which focused narrowly on supply-side resource additions to meet ever-growing customer demand. With experience, IRP planning processes are continuously evolving in both theory and application. Each utility's IRP process is different—reflecting its system characteristics and planning needs, corporate culture and organization, and regulatory environment. However, every IRP process follows a general framework in evaluating **a** broad range of resource options to develop along-term resource plan typically covering 20 to 30 years, and an action plan covering from two to five years. New or revised integrated resource plans are prepared on average every two to five years. Figure 5-1 shows a simplified IRP process.

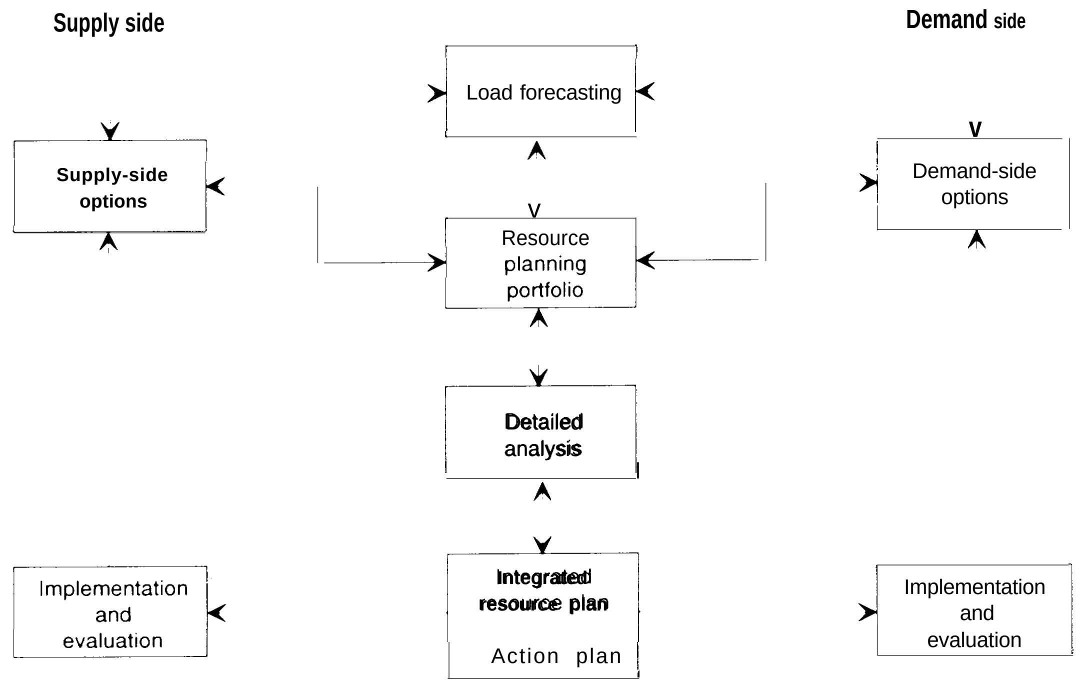
The process typically begins with preparation of long-term load forecasts projecting both energy sales (megawatt-hours) and peak demand (megawatts) over the planning period. The forecasts are based on historical consumption data, weather, population, and economic data, and electric equipment use. The load forecasts must also take into account expected load growth and potential changes in energy consumption patterns due to new technologies, DSM programs, and other conservation measures. The detailed forecasts are used for financia1 and resource planning to identify an appropriate mix of generation, transmission, distribution, power purchase, and energy efficiency options to meet system needs under a range of alternative future scenarios.

Using the initial load forecasts, utility planners then survey potential demand- and supply-side resource options to identify appropriate measures for inclusion in the integrated resource planning portfolio.

For supply-side options, planners will consider existing generation, transmission and distribution resources, utility generating plant additions, life extensions and efficiency upgrades, plant retirements, power purchases, and improvements to transmission and distribution facilities. During this initial evaluation, planners will compare the resources on considerations of: load profiles, reliability and dispatch capabilities; capital, fuel, operating, and maintenance costs; environmental and siting requirements; and capital availability. The result will be a supply-side resource stack.

Demand-side options will be identified based on considerations of existing customer use patterns, availability of energy-efficient technologies, demographic data, and evaluations of existing utility DSM programs. Planners will estimate

Figure 5-1-Simpl ified Integrated Resource Planning Framework



SOURCE: Office of Technology Assessment, 1993.

costs, load impacts, and participation rates to produce an initial stack of demand-side resources.

The IRP process then proceeds to detailed and iterative evaluation of the potential resource options to identify the best resource mix taking into consideration the utility's strategic goals, load profile impacts, production and capital costs, revenue requirements, rate impacts, environmental and other regulatory requirements, and other planning uncertainties. Planning uncertainties related to demand-side resources include participation rates, and the costs, effectiveness, durability, and verification of efficiency measures. For supply resources, uncertainties include construction time and costs, regulatory approvals, fuel availability and costs, operating and maintenance costs, and public attitudes towards the technology and the specific facility proposed. Overall uncertainties complicating resource planning affecting load growth and costs include impacts of inflation and interest rates, changing economic conditions, availability of purchased power, and changes in environmental and economic regulatory policies. During the process, resources may be added or removed from the portfolio based on the initial evaluation.

The typical IRP process includes opportunities for participation by the public and by regulators. The extent and type of participation vary. Some utilities have relied upon a collaborative consultation with interested parties over the entire course of plan preparation. Others may prepare a draft plan and then solicit public and regulatory comment before preparing a final plan.

The costs and benefits of alternative resource options are compared individually and in combination and they are ranked according to the appropriate cost-effectiveness test and planning goals. This cost-benefit ranking may be conducted under a number of separate scenarios with different assumptions about factors affecting energy demand, financial conditions, or regulatory requirements. In selecting a final integrated resource stack, planners must balance many different and sometimes competing goals and expectations about the future. Because resource planning involves many qualitative and strategic judgments, a least-cost plan will not always be the option that minimizes power production costs. Considerations of reliability, flexibility, resource diversity, and business strategy/policy may outweigh options that are the cheapest alternatives at the time the plan is developed.

The integrated resource plan lays out the utility's least-cost long-term strategy. It is coupled with a short- to mid-term action plan that details the specific actions and resource additions that the utility will take to carry out the plan objectives. Based on the plan, the utility, with any necessary regulatory approvals, will proceed to plan and acquire the preferred supply- and demand-side resources to meet customer loads. During implementation of the plan, adjustments can be made to reflect changing conditions using the plan as a guide. The utility's experience in implementing the action plan and evaluating its results are then used in the next round of the IRP process.